Supplement material

Full title

Dietary nutrient profiles of wild wolves: insights for optimal dog nutrition?

Running title

Nutrient intake in wild wolves

Authors

Guido Bosch[1]*, Esther A. Hagen-Plantinga[2], Wouter H. Hendriks[1,2]

[1]Animal Nutrition Group, Wageningen University, PO Box 338, 6700 AH Wageningen, The Netherlands

[2]Faculty of Veterinary Medicine, Utrecht University, PO Box 80.151, 3508 TD Utrecht, The Netherlands

*Corresponding author, tel. +31 317 482982, guido.bosch@wur.nl, Animal Nutrition Group, Wageningen University, PO Box 338, 6700 AH Wageningen, The Netherlands

1 Materials and methods

The wolf's foraging ecology was reviewed and nutrient composition data of the different dietary items, and in the case of large prey species, their body tissues were obtained from the literature. Data on diet compositions and nutrient composition of consumed dietary items were combined to calculate the nutrient profile of diets of wild wolves reported in the literature. All data were collected by manual electronic literature searches conducted in Scopus, Web of Science and Google Scholar. These initial searches were supplemented by reference and citation tracking. The review of literature ended in October 2012.

1.1 Diet composition

Potential eligible studies reporting diet compositions of wolves, whole-body nutrient composition of non-ungulate prey species and organ nutrient composition for ungulates were collected. As opposed to our previous study in wild cats, studies reporting frequency of occurrence of dietary items were not used as mean values for weight classes of young ungulates and weighted values on the population structure of adult ungulates required for conversion to percentage of weight (PW) were generally not available. As such only studies expressing each dietary item consumed as PW of the total biomass consumed by wolves were considered eligible. When studies reported details on age classes (i.e. fawns/calves/piglets and (sub)adults), these were taken into account in further calculations (see below) but these details are not presented in the summarising table on diet compositions. If age class was not specified in a study, an assumed age class distribution was applied to take differences in body composition and extent of consumption (see below) into account. Based on diet composition data, the average age class composition in summer for caribou or reindeer (*Rangifer tarandus*), moose or elk in Europe (*Alces alces*), and white-tailed deer (*Odocoileus virginianus*) was approximately 85% adults and 15% calves/fawns and for wild boar (*Sus scrofa*) 50% adults and 50% piglets throughout the year. Wagner *et al.* presented the average percentage adults and juveniles of roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and wild boar over 8 years, and these

percentages were applied for diet composition of each year of the study. The distribution between adults and juveniles in fallow deer (*Dama dama*) was calculated as the average of that in roe and red deer, i.e. 68% adults and 32% juveniles. Furthermore, it was assumed that during the winter period the ungulates have a body composition resembling that of an adult and are consumed by wolves as such. For studies reporting year-round data, the average age class distribution for summer and winter was used. Studies on the diet compositions of wild wolves most often estimated the PW of various dietary items (animals and vegetation) based on stomach or scat analyses. Dietary items were identified by bone, hair, feather remains and other undigested material in collected stomachs or scats according to described taxonomic keys and/or own reference material of the researchers. Studies with a stomach or scat sample size lower than 94 stomachs or scats were not included in the present study (see Trites & Joy). To guarantee the 'wild' and 'human-independent' feeding behaviour of the wolves, studies in which human-linked foods (e.g., food scraps, garbage, livestock) contributed more than 5% of the consumed biomass were excluded.

1.2 Ungulate body composition

Data on the weights of main body tissues included muscle, heart, liver, lungs, spleen, kidneys, pancreas, separable fat, bones, bone marrow, blood, empty stomach (rumen, reticulum, omasum, and abomasum), empty intestines (small and large), brain, hide, and hooves as a percentage of total body mass of ungulates were collected. As data on the diet composition in literature are most often relatively general in nature (e.g. PW for adult ungulate or fawn of unknown gender), studies reporting more specific data on ungulate body composition according to gender were averaged and data on specific ages of animals were averaged by the age classes young fawns/calves/piglets and (sub)adults (>12 months). Data on specific ages within these classes and data from multiple studies on the same animal species were averaged and presented as such. Ingesta-free body composition data for white-tailed deer presented by McCullough & Ullrey were corrected for weight of digesta accounting for 13.95% of BW in adults and 4.85% of BW in fawns. The body

compositions of caribou, muskox, red deer, white-tailed deer, and wild boar are shown in the Table S1. Where data for body tissues within age class were missing, data from the other ruminant ungulate species were used. Ruminant ungulates were classified according to Hofmann and Bodmer as concentrate selectors and intermediate types. Concentrate selectors were white-tailed deer, black-tailed deer (*O. h. columbianus*), roe deer, moose, and fallow deer and intermediate ruminant type ungulates were red deer or elk, caribou, chamois (*Rupicapra rupicapra*), mountain goats (*Oreamnos americanus*), mouflon (*Ovis aries orientalis*), and muskox (*Ovibos moschatus*). Concentrate selectors were assumed to have a similar body composition as white-tailed deer. For intermediate types, chamois, mountain goats, and mouflon were assumed to be similar in body composition as adult red deer. The body composition of muskox was used to be representative for the European bison (*Bison bonasus*). Body composition of unknown ungulates was taken to be the average of that of caribou (adult), muskox, red deer (adult), and white-tailed deer (adult).

1.3 Prey consumption

As consumption of large ungulates is selective and not complete, the extent of body tissue consumption (in percentage) was based on prey consumption behaviour of wolves as described by Stahler *et al.*. It was assumed that half of the blood is spilled during hunting, killing, and consuming of adult prey animals and the other half of the blood remained in the tissues. The assumed extent of consumption for different body tissues of ungulate prey is presented in Table S2.

1.4 Nutrient composition of dietary items

The nutrient composition of ungulate body tissues required for the calculation of diet composition are shown in the Table S3. No data were found for the micronutrient and trace elements of hair and hooves as well as the K contents of separable fat and marrow and were therefore set at 0. Contents of micronutrients and trace elements of the spinal cord were assumed to be similar as those of the brain. Age classes of ungulates were assumed not to

differ in nutrient composition of specific body tissues. Where data for nutrient composition were unavailable, the average composition of other ungulate species was used taking into account feeding strategy (i.e. concentrate selector or intermediate type) where possible. The intermediate types of ungulates (i.e. chamois, mountain goats, mouflon, and muskox), wild boar, European bison, and livestock were assumed to be similar in nutrient composition of body tissues as adult red deer. Nutrient composition of body tissues from unknown ungulates was taken to be equal to the average composition of caribou (adult), muskox, red deer (adult), and white-tailed deer (adult) while European bison and livestock were used for muskox. For beavers, the average composition of rodents and medium-size mammals was used and for cats, dogs, bears, and lynxes the average composition of arctic blue fox (*Alopex lagopus*) and red fox (*Vulpes vulpes*) was used. Vegetable matter and 'other' dietary items were not included as these were not sufficiently specified to allow further calculations. Composition data of berries which are consumed under specific circumstances (see below) is presented in Table S4. The N-free extract (NFE) content was calculated by difference as 100 – CP – ethereal extract (EE) – ash contents. For large ungulates, it was assumed that the liver and muscles were the only body tissues with carbohydrates (i.e. glycogen). The NFE content was only calculated for the liver, estimated to be 1.2 % of DM in muscle (based on average NFE content for available muscle data) and assumed to be 0 for all other body tissues. As the sum of values for CP, EE and Ash derived from literature was generally not 100%, values for each of these parameters were corrected by multiplying by (CP+EE+Ash)/100. The estimated mean metabolisable energy (ME in kJ) content of ungulate body tissues and non-ungulate prey were calculated using modified Atwater factors as (3.5 × CP + 8.5 × EE + 3.5 × NFE) × 4.1868.

1.5 Calculations of nutrient intake

The nutrient composition of study diets and simulated diets was calculated by combining the PW for each dietary item, ungulate body tissue composition, extent of consumption of body tissues, and nutrient compositions of body tissues and non-ungulate preys. Nutrient intake was based on the body tissues

actually consumed, by dividing percentage values for consumed body tissues by the sum of percentages of all consumed body tissues and multiplied by 100. Furthermore, for each diet, the PW of each item was corrected for the sum PW of all dietary items excluding the categories ‘Vegetation’ and ‘Other’ (together on average 1% of the diets), making the calculated dietary nutrient profiles based on an average of 97.8% of total PW. Data entry, management, and statistical descriptive analyses were conducted using Windows Microsoft Excel 2010 (Microsoft Corp., Seattle, WA, USA).

References

1. Plantinga EA, Bosch G & Hendriks WH (2011) Estimation of the dietary nutrient profile of free-roaming feral cats: possible implications for nutrition of domestic cats. *Br J Nutr* **106**, S35-S48.

2. Floyd TJ, Mech LD & Jordan PA (1978) Relating wolf scat content to prey consumed. *J Wildlife Manage* **42**, 528-532.

3. Ballard WB, Whitman JS & Gardner CL (1987) Ecology of an exploited wolf population in South-Central Alaska. *Wildlife Monogr* **98**, 3-54.

4. Tremblay J-P, Jolicoeur H & Lemieux R (2001) Summer food habits of gray wolves in the boreal forest of the Lac Jacques-Cartier highlands Québec. *Alces* **37**, 1-12.

5. Forbes GJ & Theberge JB (1996) Response by wolves to prey variation in central Ontario. *Can J Zool* **74**, 1511-1520.

6. Fuller TK & Keith LB (1980) Wolf population dynamics and prey relationships in northeastern Alberta. *J Wildlife Manage* **44**, 583-602.

7. Messier F & Crête M (1985) Moose-wolf dynamics and the regulation of moose populations. *Oecologia* **65**, 503-512.

8. Peterson RO (1977) Wolf ecology and prey relationships on Isle Royale. Ph.D. thesis, Purdue University, West Lafayette, IN, U.S.

9. Peterson RO & Page RE (1988) The rise and fall of Isle Royal wolves, 1975-1986. *J Mammal* **69**, 89-99.

10. Potvin F, Jolicoeur H & Huot J (1988) Wolf diet and prey selectivity during two periods for deer in Quebec: decline versus expansion. *Can J Zool* **66**, 1274-1279.

11. Thurber JM & Peterson RO (1993) Effects of population density and pack size on the foraging ecology of gray wolves. *J Mammal* **74**, 879-889.
12. Fuller TK (1989) Population dynamics of wolves in North-Central Minnesota. *Wildlife Monogr* **105**, 1-41.
13. Capitani C, Bertelli I, Varuzza P *et al.* (2004) A comparative analysis of wolf (*Canis lupus*) diet in three different Italian ecosystems. *Mamm Biol* **69**, 1-10.
14. Wagner C, Holzapfel M, Kluth G *et al.* (2012) Wolf (*Canis lupus*) feeding habits during the first eight years of its occurrence in Germany. *Mamm Biol* **77**, 196-203.
15. Trites AW & Joy R (2005) Dietary analysis from fecal samples: How many scats are enough? *J Mammal* **86**, 704-712.
16. McCoullough DR & Ullrey DE (1983) Proximate mineral and gross energy composition of white-tailed deer. *J Wildlife Manage* **47**, 430-441.
17. Robbins CT, Moen AN & Reid JT (1974) Body composition of white-tailed deer. *J Anim Sci* **38**, 871-876.
18. Hofmann RR (1989) Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* **78**, 443-457.
19. Bodmer RE (1990) Ungulate frugivores and the browser-grazer continuum. *Oikos* **57**, 319-325.
20. Stahler DR, Smith DW & Guernsey DS (2006) Foraging and feeding ecology of the gray wolf (*Canis lupus*): lessons from Yellowstone National Park, Wyoming, USA. *J Nutr* **136**, S1923-S1926.
21. National Research Council (2006) *Nutrient requirements of dogs and cats*. Washington, DC: National Academy Press.
22. Borch-Iohnsen B, Nilssen KJJ & Norheim G (1996) Influence of season and diet on liver and kidney content of essential elements and heavy metals in Svalbard reindeer. *Biol Trace Elem Res* **51**, 235-247.
23. Chan-McLeod ACA, White RG & Russell DE (1995) Body mass and composition indices for female barren-ground caribou. *J Wildlife Manage* **59**, 278-291.

24. Gerhart KL, White RG, Cameron RD *et al.* (1996) Body composition and nutrient reserves of arctic caribou. *Can J Zool* **74**, 136-146.
25. Knott KK, Barboza PS & Bowyer RT (2005) Growth in arctic ungulates: Postnatal development and organ maturation in *Rangifer tarandus* and *Ovibos moschatus*. *J Mammal* **86**, 121-130.
26. Reimers E, Ringberg T & Sørumgård R (1982) Body composition of Svalbard reindeer. *Can J Zool* **60**, 1812-1821.
27. Ringberg TM, White RG, Holleman DF *et al.* (1981) Body growth and carcass composition of lean reindeer (*Rangifer tarandus tarandus L.*) from birth to sexual maturity. *Can J Zool* **59**, 1040-1044.
28. Adamczewski JZ, Flood PF & Gunn A (1995) Body composition of muskoxen (*Ovibos moschatus*) and its estimation from condition index and mass measurements. *Can J Zool* **73**, 2021-2034.
29. Adamczewski JZ, Flood PF & Gunn A (1997) Seasonal patterns in body composition and reproduction of female muskoxen (*Ovibos moschatus*). *J Zool* **241**, 245-269.
30. Grace ND, Castillo-Alcala F & Wilson PR (2008) Amounts and distribution of mineral elements associated with liveweight gains of grazing red deer (*Cervus elaphus*). *New Zeal J Arg Res* **51**, 439-449.
31. Houston DB (1978) Elk as winter-spring food for carnivores in northern Yellowstone National Park. *J Appl Ecol* **15**, 653-661.
32. Meadows SD & Hakonson TE (1982) Contribution of tissues to body mass in elk. *J Wildlife Manage* **46**, 838-841.
33. Robinson PF (1966) Organ: Body weight relationships in the white-tailed deer, *Odocoileus virginianus*. *Chesap Sci* **7**, 217-218.
34. Verme LJ & Ozoga JJ (1980) Influence of protein-energy intake on deer fawns in autumn. *J Wildlife Manage* **44**, 305-314.
35. Watkins BE, Witham JH & Ullrey DE (1992) Body composition changes in white-tailed deer fawns during winter. *Can J Zool* **70**, 1409-1416.
36. Watkins BE, Witham JH, Ullrey DE *et al.* (1991) Body composition and condition evaluation of white-tailed deer fawns. *J Wildlife Manage* **55**, 39-51.

24837. Müller E, Moser G, Bartenschlager H *et al.* (2000) Trait values of growth, 249carcass and meat quality in Wild Boar, Meishan and Pietrain pigs as well as 250their crossbred generations. *J Anim Breed Genet* **117**, 189-202.
25138. Skewes O, Morales R, González F *et al.* (2008) Carcass and meat quality 252traits of wild boar (*Sus scrofa s. L.*) with 2n = 36 karyotype compared to those 253of phenotypically similar crossbreeds (2n = 37 and 2n = 38) raised under 254same farming conditions. 1. Carcass quantity and meat dressing. *Meat Sci* **80**, 2551200-1204.
25639. CNF (2010) Canadian Nutrient File: Nutrition Research Division, Health 257Products and Food Branch, Health Canada.
25840. Kuhnlein HV, Chan HM, Leggee D *et al.* (2002) Macronutrient, mineral 259and fatty acid composition of Canadian arctic traditional food. *J Food Comp* 260*Anal* **15**, 545-566.
26141. Heller CA & Scott EM (1967) *The Alaska diet survey, 1956-1961*. 262Anchorage, AK, U.S.: Arctic Health Research Center, Nutrition and Metabolic 263Disease Section, Public Health Services, DHEW.
26442. Kuhnlein HV, Appavoo D, Morrison N *et al.* (1994) Use and nutrient 265composition of traditional Sahtú (Hareskin) Dene/Métis foods. *J Food Comp* 266*Anal* **7**, 144-157.
26743. Nobmann E (1993) Nutrient value of Alaska native foods, pp. 44 268[USDoHaH Services, editor]. Anchorage, AK, U.S.: Alaska Area Native Health 269Service.
27044. Zomborszky Z, Szentmihályi G, Sarudi I *et al.* (1996) Nutrient composition 271of muscles in deer and boar. *J Food Sci* **61**, 625-627.
27245. Rudy M (2010) Chemical composition of wild boar meat and relationship 273between age and bioaccumulation of heavy metals in muscle and liver tissue. 274*Food Addit Contam, Part A* **27**, 464-472.
27546. Kuhnlein HV & Soueida R (1992) Use and nutrient composition of 276traditional Baffin Inuit foods. *J Food Comp Anal* **5**, 112-126.
27747. Cordain L, Watkins BA, Florant GL *et al.* (2002) Fatty acid analysis of wild 278ruminant tissues: evolutionary implications for reducing diet-related chronic 279disease. *Eur J Clin Nutr* **56**, 181-191.

28048. Litvaitis JA & Mautz WW (1980) Food and energy use by captive coyotes. *J*
281*Wildlife Manage* **44**, 56-61.
28249. Powers JG, Mautz WW & Pekins PJ (1989) Nutrient and energy
283assimiliation of prey by bobcats. *J Wildlife Manage* **53**, 1004-1008.
28450. Davison RP, Mautz WW, Hayes HH *et al.* (1978) Efficiency of food
285utilization and energy requirements of captive female fishers. *J Wildlife*
286*Manage* **42**, 811-821.
28751. Lefebvre C, Crete M, Huot J *et al.* (1999) Prediction of body composition of
288live and post-mortem red foxes. *J Wildlife Dis* **35**, 161-170.
28952. Prestrud P & Nilssen K (1992) Fat deposition and seasonal variation in
290body composition of arctic foxes in Svalbard. *J Wildlife Manage* **56**, 221-233.
29153. Korhonen H (1988) Seasonal comparison of body composition and hair
292coat structure between mink and polecat. *Comp Biochem Physiol A* **91**, 469-
293473.
29454. Buskirk SW & Harlow HJ (1989) Body fat dynamics of the American
295marten (*Martes americana*) in Winter. *J Mammal* **70**, 191-193.
29655. Garant Y & Crête M (1999) Prediction of water, fat, and protein content of
297fisher carcasses. *Wildl Soc Bull* **27**, 403-408.
29856. Shields Jr RG, Mahan DC & Graham PL (1983) Changes in swine body
299composition from birth to 145 kg. *J Anim Sci* **57**, 43-54.
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Table S1. Composition of various tissues of ungulates (in % of total body mass).

Species*	Age class	Body tissue†															Total
		Musc	Hea	Liv	Lun	Sple	Kidn	Panc	SFat	Marr	Bloo	Stom	Inte	Brain	Bone	Hide	Hoov	
Caribou	Fawn	37.27	1.17	2.50	-	-	0.53	-	-	-	-	1.58	3.20	1.40	18.20	-	-	67.77
	Adult	36.00	1.15	1.61	-	-	0.27	-	14.31	-	-	2.98	1.91	0.39	10.98	8.84	-	80.64
Muskox	General‡	37.61	0.53	1.36	-	0.13	0.28	-	3.22	-	-	5.15	-	-	15.91	-	-	64.19
Red deer	Fawn	45.21	0.99	2.61	2.75	0.18	0.40	0.07	-	-	7.09	1.49	2.80	1.46	17.11	13.94	-	96.10
	Adult	45.52	0.72	1.34	1.37	0.63	0.23	0.07	-	-	7.03	2.42	2.49	0.36	11.69	6.92	-	81.04
White-tailed deer	Fawn	49.12	0.86	1.65	1.20	0.28	0.24	0.11	5.78	0.50	4.93	-	-	0.40	8.40	7.01	0.28	80.76
	Adult	45.11	0.65	1.38	-	0.28	0.24	-	11.07	0.36	5.57	-	-	0.25	6.76	6.81	0.22	78.70
Wild boar	Adult	43.59	0.41	2.17	1.19	0.22	0.38	-	15.81	-	4.17	-	-	-	11.59	17.00	-	96.53

*References caribou: Borch-Iohnson *et al.*, Chan-McLeod *et al.*, Gerhart *et al.*, Knott *et al.*, Reimers *et al.*, Ringberg *et al.*; muskox: Adamczewski *et al.*, Knott *et al.*; red deer: Grace *et al.*, Houston, Meadows & Hakonson; white-tailed deer: McCullough & Ullrey, Robinson, Verme & Ozoga, and Watkins *et al.*; wild boar: Müller *et al.*, Skewes *et al.*.

†Musc, muscle; Hea, heart; Liv, liver; Lun, lungs, Sple, spleen; Kidn, kidneys; Panc, pancreas; SFat, separable fat; Marr, marrow; Bloo, blood; Stom, stomach; Inte, intestines; Hoov, hooves; -, data were not available.

‡Average of calf and adult.

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Table S2. Assumed extent of consumption (in % of total) for different body tissues of young and adult ungulate prey.

Animal tissue	Young	Adult
Muscle	100	100
Heart	100	100
Liver	100	100
Lungs	100	100
Spleen	100	100
Kidneys	100	100
Pancreas	100	100
Separable fat	100	100
Marrow	75	30
Blood	50	50
Stomach	100	80
Intestines	100	80
Brain	50	10
Bone	75	30
Spinal cord	5	0
Hide	50	20
Hooves	0	0
Digesta	0	0

313**Table S3.** Nutrient composition of ungulate body tissues.

Body tissue	**Content***													**References**
	%	**g/100 g DM**									**mg/100 g DM**			
	DM	**CP**	**EE**	**NFE**	**Ash**	**Ca**	**P**	**Na**	**K**	**Mg**	**Cu**	**Fe**	**Zn**	
Ungulate														
Muscle														
Bison	25.4	86.9	8.2	1.2	3.8	0.02	0.74	0.21	1.35	98	0.35	10.2	11.01	
Caribou	28.1	82.7	12.4	1.2	3.7	0.03	0.80	0.21	0.97	99	0.92	16.8	15.55	
Fallow deer	25.2	85.1	12.4	1.2	3.7	0.06	0.88	0.28	1.20	85	0.76	10.3	12.49	
Moose	26.4	86.9	8.2	1.2	3.8	0.07	0.77	0.24	1.36	103	0.37	15.1	16.29	
Muskox	25.0	84.5	8.9	1.2	5.3	0.01	0.64	0.20	1.68	100	0.52	18.0	9.60	
Red deer	22.6	90.9	3.5	1.2	4.5	0.05	0.72	0.25	1.33	88	0.77	14.6	15.31	
Roe deer	25.5	88.0	6.5	1.2	4.3	0.07	0.91	0.23	1.34	85	0.85	10.3	11.35	
White-tailed deer	29.4	75.6	19.6	1.2	3.6	0.03	0.61	0.17	1.33	72	0.66	10.3	12.35	
Wild boar	25.5	84.5	10.3	1.2	4.5	0.05	0.80	0.26	1.20	76	0.63	9.5	14.31	
Heart														
Caribou	24.4	78.7	16.8	0.0	4.5	0.02	0.79	0.47	1.71	85	1.84	40.8	7.59	
Red deer	-	-	-	0.0	-	0.02	1.00	0.34	1.34	107	1.94	23.8	11.10	
White-tailed deer	24.3	80.3	15.3	0.0	4.4	0.03	0.74	0.30	1.35	80	1.80	20.5	7.68	
Liver														
Caribou	28.7	66.8	13.6	14.6	5.0	0.01	1.05	0.28	1.09	68	12.50	96.9	13.21	

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Moose	29.5	72.1	9.7	14.3	3.9	0.01	1.18	0.29	0.48	55	6.90	48.3	7.59
Red deer	-	-	-	-	-	0.02	1.20	0.37	0.96	55	2.70	48.5	10.30
White-tailed deer	31.0	69.5	8.1	18.6	3.8	0.01	0.67	0.23	0.88	56	5.91	65.3	8.35
Lungs													
Caribou	23.0	86.1	9.8	0.0	4.1	0.05	0.99	0.80	-	52	0.87	100.0	6.52
Moose	21.0	86.1	9.6	0.0	4.3	0.05	0.83	0.70	1.13	48	0.57	85.7	5.71
Red deer	-	-	-	0.0	-	0.04	0.92	0.69	0.07	52	0.46	71.2	6.70
Spleen													
Beef	22.8	80.6	13.2	0.0	6.2	-	-	-	-	-	-	-	-
Red deer	-	-	-	0.0	-	0.02	0.47	0.31	1.29	31	0.23	232.8	5.90
Kidneys													
Moose	21.0	87.2	6.7	0.0	6.2	0.03	-	-	-	81	1.90	27.1	14.29
Red deer	-	-	-	0.0	-	0.04	1.17	0.91	1.03	69	2.12	6.3	12.30
Pancreas													
Beef	34.8	44.1	52.2	0.0	3.7	-	-	-	-	-	-	-	-
Red deer	-	-	-	0.0	-	0.06	1.35	0.38	1.40	89	0.53	24.0	5.40
Separable fat													
Caribou	95.3	3.2	96.8	0.0	-	0.00	0.05	0.04	-	7	-	3.2	0.42
Moose	95.0	2.1	97.8	0.0	0.0	-	-	-	-	-	-	-	-
White-tailed deer	95.8	1.1	98.9	0.0	0.1	-	-	-	-	-	-	-	-
Stomach													
Caribou	22.0	78.9	11.0	0.0	10.1	1.09	1.48	0.59	-	177	0.91	109.1	15.91
Red deer	-	-	-	0.0	-	0.07	1.15	0.62	1.12	79	1.03	63.0	10.00
Intestine													

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Pig	23.9	31.2	67.9	0.0	0.8	-	-	-	-	-	-	-	-
Red deer	-	-	-	0.0	-	0.06	0.72	0.37	0.96	81	0.44	17.8	9.05
Blood													
Moose	21.0	94.2	2.2	0.0	3.6	0.01	0.08	0.30	0.84	10	0.14	295.2	0.95
White-tailed deer	20.2	90.8	5.3	0.0	3.9	-	-	-	-	-	-	-	-
Brain													
Caribou	22.0	51.5	42.0	0.0	6.5	0.32	1.71	0.69	-	64	0.91	21.4	4.55
Red deer	-	-	-	0.0	-	0.07	1.34	0.65	1.13	59	0.78	7.2	6.10
White-tailed deer	22.3	50.1	45.9	0.0	4.1	0.07	0.15	0.70	1.78	70	0.84	13.4	5.12
Spinal cord													
White-tailed deer	34.1	26.8	71.5	0.0	1.7	-	-	-	-	-	-	-	-
Bones													
Red deer	-	-	-	0.0	-	14.39	8.65	0.66	0.63	288	0.05	6.0	11.60
White-tailed deer	71.4	29.8	11.6	0.0	58.6	34.08	15.75	0.77	0.05	634	0.99	11.1	9.27
Marrow													
Caribou	91.8	7.3	92.2	0.0	0.4	0.00	0.07	0.03	-	2	0.00	3.9	0.11
Moose	56.0	16.8	82.1	0.0	1.1	0.08	-	-	-	45	0.09	3.6	1.79
White-tailed deer	88.4	1.5	98.2	0.0	0.3	-	-	-	-	-	-	-	-
Hide													
Caribou†	-	90.7	7.7	0.0	1.6	-	-	-	-	-	-	-	-
Red deer	-	-	-	0.0	-	0.04	0.18	0.39	0.35	19	0.20	6.1	7.80
White-tailed deer†	68.9	91.2	7.9	0.0	0.9	0.08	0.05	0.08	0.03	12	0.64	4.5	2.72
Hooves													
White-tailed deer	44.2	98.6	0.9	0.0	0.5	0.00	0.00	0.00	0.00	0	0.00	0.0	0.00

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DM, dry matter; CP, crude protein; EE, ether-extract; NFE, N-free extract.

-, not indicated.

*NFE content was only calculated for the liver, estimated to be 1.2 % of DM in muscle (based on average NFE content for available muscle data) and assumed to be 0 for all other body tissues. As the sum of values for CP, EE and Ash derived from literature was generally not 100%, values for each of these parameters were corrected by multiplying by (CP+EE+Ash)/100.

†Calculated based on a hair to skin ratio of 2.1 to 1 as found for white-tailed deer.

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321**Table S4.** Nutrient composition of dietary items of the wild wolf diets.

Dietary item	**Content**													**References**
	%	**g/100 g DM**								**mg/100 g DM**				
	DM	**CP**	**EE**	**NFE**	**Ash**	**Ca**	**P**	**Na**	**K**	**Mg**	**Cu**	**Fe**	**Zn**	
Ungulates														
Moose adult	38.9	69.9	24.2	1.0	4.8	1.05	1.07	0.26	1.02	95	0.48	29.0	11.98	This study
Moose calf	37.0	73.0	18.0	1.1	7.9	2.88	1.92	0.30	1.04	130	0.55	26.6	12.68	This study
White-tailed deer adult	40.9	62.4	31.8	1.1	4.7	1.02	0.96	0.21	1.02	75	0.65	26.3	9.47	This study
White-tailed deer fawn	39.1	65.5	25.5	1.2	7.8	2.85	1.80	0.26	1.03	109	0.72	24.0	10.16	This study
Red deer adult	39.0	68.9	24.0	1.0	6.1	0.70	0.95	0.26	0.96	76	0.59	28.2	10.92	This study
Red deer fawn	38.7	72.1	14.9	1.1	11.9	2.17	1.82	0.35	0.96	101	0.60	26.9	11.66	This study
Roe deer adult	38.3	70.5	23.3	1.1	5.2	1.05	1.16	0.25	1.02	84	0.78	26.1	8.82	This study
Roe deer fawn	36.5	73.6	17.0	1.1	8.3	2.88	2.00	0.30	1.03	118	0.85	23.7	9.50	This study
Fallow deer adult	38.2	68.6	25.3	1.1	5.0	1.04	1.14	0.28	0.93	84	0.73	26.1	9.55	This study
Fallow deer fawn	36.3	71.8	19.1	1.1	8.1	2.87	1.98	0.32	0.94	118	0.80	23.7	10.24	This study
Caribou adult	44.1	62.1	31.1	1.0	5.8	0.76	1.00	0.25	0.75	82	0.91	35.2	10.63	This study
Caribou calf	43.0	65.8	20.4	1.0	12.7	2.50	2.03	0.34	0.80	111	0.97	32.6	11.53	This study
Wild boars adult	42.5	62.8	30.1	1.1	6.0	0.70	1.00	0.27	0.86	68	0.52	20.4	10.18	This study
European bison	32.	76.4	15.2	1.1	7.3	0.78	1.10	0.28	1.11	92	0.42	29.9	9.56	This

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	5												study
Mouflon	39.0	68.9	24.0	1.0	6.1	0.70	0.95	0.26	0.96	76	0.59	28.2	10.92	This study
Mountain goats	39.0	68.9	24.0	1.0	6.1	0.70	0.95	0.26	0.96	76	0.59	28.2	10.92	This study
Livestock	32.2	74.9	16.2	1.1	7.6	0.77	1.03	0.27	1.33	93	0.53	35.1	8.61	This study
Unknown ungulate	39.4	66.8	26.2	1.0	6.0	0.88	1.01	0.25	1.00	83	0.67	31.0	9.96	This study
Non-ungulates														
Beavers	35.5	58.5	24.8	3.9	12.8	2.78	2.08	0.43	1.06	96	1.19	28.9	10.68	This study
Bears, cats, dogs, lynxes	38.8	55.2	28.8	2.4	13.6	2.65	1.95	0.47	1.02	118	1.33	29.4	9.99	This study
Hares or rabbits*	31.9	71.8	6.2	4.9	15.7	2.40	1.70	0.54	0.94	160	1.60	30.2	8.60	
Insectivora	31.2	61.6	19.0	4.5	14.9	3.44	1.72	0.42	1.05	140	1.18	50.0	12.00	
Medium-size mammals†	38.8	55.2	28.8	2.4	13.6	-	-	-	-	-	-	-	-	
Mustelidae‡	38.1	39.6	44.4	5.6	10.4	-	-	-	-	-	-	-	-	
Rodents**	32.1	61.8	20.9	5.4	12.0	2.90	2.20	0.39	1.10	75	1.06	28.5	11.38	
Squirrels	31.1	65.5	22.1	0.0	12.4	3.50	1.90	0.83	1.07	140	0.87	25.3	10.20	
Wild boar piglets††	23.2	54.9	24.2	6.9	14.0	-	-	-	-	-	-	-	-	
Birds	31.6	64.6	15.9	8.9	10.6	3.00	2.10	0.38	0.66	100	1.26	49.6	11.50	
Vegetation														
Raspberries	21.0	3.3	3.3	71.4	2.3	0.22	0.17	0.00	0.84	138	0.29	4.8	1.90	

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Blueberries	12.8	4.9	11.0	76.0	2.0	0.11	0.11	0.01	0.74	73	0.60	1.8	2.21

DM, dry matter; CP, crude protein; EE, ether-extract; NFE, N-free extract.

-, not indicated.

*Macronutrients from Davison *et al.*, Litvaitis & Mautz, and Powers *et al.*, and micronutrients and trace elements in rabbits from Plantinga *et al.*.

†Average of skinned arctic blue fox (*Alopex lagopus*) from Prestrud & Nilssen and ingesta-free red fox (*Vulpes vulpes*) from Lefebvre *et al.*.

‡Average of American marten (*Martes Americana*) from Buskirk & Harlow, fisher (*Martes pennant*) from Garant & Crête, and mink (*Mustela vison*) and polecat (*Mustela purorius*) from Korhonen.

**Average composition of mice and voles presented by Plantinga *et al.*.

††Calculated as the average of crossbred (Hampshire, Yorkshire, Duroc) piglets of 1.5 kg and 6.4 kg in BW.

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